



**Designation: A 962/A 962M – 01**

An American National Standard

## **Standard Specification for Common Requirements for Steel Fasteners or Fastener Materials, or Both, Intended for Use at Any Temperature from Cryogenic to the Creep Range<sup>1</sup>**

This standard is issued under the fixed designation A 962/A 962M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

### **1. Scope**

1.1 This specification covers a group of common requirements that shall apply to carbon, alloy and stainless steel fasteners or fastener materials, or both, under any of the following ASTM Specifications (or under any other ASTM Specifications that invoke this specification or portions thereof):

Title of Specifications	ASTM Designation
Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service	A 193/A 193M
Carbon and Alloy Steel Nuts for Bolts for High Pressure and High-Temperature Service	A 194/A 194M
Alloy Steel Bolting Materials for Low-Temperature Service	A 320/A 320M
Alloy-Steel Turbine-Type Bolting Material Specially Heat Treated for High-Temperature Service	A 437/A 437M
High-Temperature Bolting Materials With Expansion Coefficients Comparable to Austenitic Stainless Steels	A 453/A 453M
Alloy-Steel Bolting Materials for Special Applications	A 540/A 540M

1.2 In case of conflict the requirements of the individual product specification shall prevail over those of this specification.

1.3 Additional requirements may be specified by mutual agreement between the purchaser and supplier.

1.4 Values stated in either inch-pound or SI units (metric) are to be regarded separately. The SI units are shown in brackets within the text and tables. The values stated in each system are not exact equivalents, therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification. Inch-pound units shall apply unless the “M” designation of the product specification is specified in the order.

### **2. Referenced Documents**

The following documents shall form a part of this specification to the extent specified. The latest issue shall apply unless otherwise specified.

#### *2.1 ASTM Standards:*

- A 29/A 29M Specification for Steel Bars, Carbon and Alloy, Hot-Wrought and Cold-Finished, General Requirements for<sup>2</sup>
- A 193/A 193M Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service<sup>3</sup>
- A 194/A 194M Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service<sup>3</sup>
- A 320/A 320M Specification for Alloy Steel Bolting Materials for Low-Temperature Service<sup>3</sup>
- A 370 Test Methods and Definitions for Mechanical Testing of Steel Products<sup>3</sup>
- A 437/A 437M Specification for Alloy-Steel Turbine-Type Bolting Material Specially Heat Treated for High-Temperature Service<sup>3</sup>
- A 453/A 453M Specification for High-Temperature Bolting Materials, With Expansion Coefficients Comparable to Austenitic Stainless Steels<sup>3</sup>
- A 484/A 484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings<sup>4</sup>
- A 540/A 540M Specification for Alloy-Steel Bolting Materials for Special Applications<sup>3</sup>
- A 574 Specification for Alloy Steel Socket-Head Cap Screws<sup>5</sup>
- A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment<sup>2</sup>
- A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products<sup>3</sup>
- A 788 Specification for Steel Forgings, General Requirements<sup>2</sup>
- E 3 Practice for Preparation of Metallographic Specimens<sup>6</sup>
- E 381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings<sup>6</sup>
- E 384 Test Method for Microhardness of Materials<sup>6</sup>

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.22 on Steel Forgings and Wrought Fittings for Piping Applications and Bolting Materials for Piping and Special Purpose Applications.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 01.05.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 01.01.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 01.03.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 01.08.

<sup>6</sup> *Annual Book of ASTM Standards*, Vol 03.01.

E 1417 Practice for Liquid Penetrant Examination<sup>7</sup>  
 E 1444 Practice for Magnetic Particle Examination<sup>7</sup>  
 E 1916 Guide for Identification and/or Segregation of Mixed Lots of Metals<sup>8</sup>  
 F 788/F 788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series<sup>5</sup>

## 2.2 ANSI Standards:

B1.1 Screw Threads<sup>9</sup>  
 B1.13M Metric Screw Threads – M Profile<sup>9</sup>  
 B1.2 Gages and Gaging for Unified Screw Threads<sup>9</sup>  
 B1.3M Screw Thread Gaging Systems for Dimensional Acceptability of Metric Screw Threads<sup>9</sup>  
 B18.2.1 Square and Hex Bolts and Screws<sup>9</sup>  
 B18.2.2 Square and Hex Nuts<sup>9</sup>  
 B18.2.3.5M Metric Hex Bolts<sup>9</sup>  
 B18.2.3.6M Metric Heavy Hex Bolts<sup>9</sup>  
 B18.2.4.1M Metric Hex Nuts, Style 1<sup>9</sup>  
 B18.2.4.2M Metric Hex Nuts, Style 2<sup>9</sup>  
 B18.2.4.6M Metric Heavy Hex Nuts<sup>9</sup>  
 B18.3 Hexagon Socket and Spline Socket Screws<sup>9</sup>

## 3. Terminology

### 3.1 Definitions of Terms Specific to This Standard:

3.1.1 *bar*—a solid rolled or forged section that is long in relationship to its cross-sectional dimensions with a relatively constant cross section throughout its length. See Specification A 29/A 29M for definitions relating to the production of hot wrought and cold finished bars.

3.1.2 *bolting material*—rolled or forged bars or blanks, wire, rod, threaded bar, rotary pierced or extruded seamless tubes, bored bars, or forged hollows from forged or rolled bar segments to be manufactured into bolts, screws, studs, washers, and nuts.

3.1.3 *certifying organization*—the company or association responsible for the conformance and marking of the product to the specification requirements.

3.1.4 *class*—a term used to differentiate between different heat treatment conditions or strength levels, or both, often within the same grade but sometimes within the same family of materials. May also apply to work hardened condition or strength level, or both.

3.1.5 *grade*—an alloy described individually and identified by its own designation in a table of chemical requirements within any specification.

3.1.6 *killed steel*—steel deoxidized, by addition of strong deoxidizing agents or by vacuum treatment, to reduce the oxygen content to such a level that no reaction occurs between carbon and oxygen during solidification.

3.1.7 *length, fasteners subject to full size testing*—that portion of the fastener whose body diameter is approximately the same as the nominal thread size.

3.1.8 *lot*—unless otherwise specified, a lot shall consist of:

3.1.8.1 *bolting material, heat treated in batch type furnaces*—all material of the same heat or cast of material,

condition, finish, and size subjected to the same heat treatment in one tempering charge and submitted for inspection at the same time.

3.1.8.2 *bolting material, heat treated in continuous type furnaces*—all material of the same heat or cast of material, condition, finish, and size heat treated without interruption in a continuous type furnace during an eight hour period.

3.1.8.3 *bolting material, non heat treated (strain hardened)*—all material of the same heat or cast of material, condition, reduction (cold work), finish and size.

3.1.8.4 *fasteners, machined from bolting material*—all fasteners machined from the same lot of material defined as outlined in either 3.1.8.1 or 3.1.8.2, above without any subsequent heat treatment or hot or cold forming.

3.1.8.5 *fasteners, heat treated in batch type furnaces*—all items produced by any technique (forming, machining, etc.) from the same heat or cast of material, of the same prior condition, the same size, and subjected to the same heat treatment in one tempering charge.

3.1.8.6 *fasteners, heat treated in continuous type furnaces*—all items produced by any technique (forming, machining, etc.) from the same heat or cast of material, of the same prior condition, of the same size, subjected to the same heat treatment in a four hour period and in one tempering charge.

3.1.8.7 *fasteners, non heat treated (strain hardened)*—all fasteners of the same heat or cast of material, condition, reduction (cold work), finish and size.

3.1.8.8 *strain hardened material*—austenitic stainless steel material which has been subjected to cold working sufficient to cause a significant increase in strength.

## 4. Ordering Information

4.1 It is the purchaser's responsibility to specify in the purchase order all information necessary to purchase the needed material. Examples of such information include, but are not limited, to the following:

4.1.1 Quantity and size,

4.1.2 Product specification number with grade, class, type, as applicable, and including the product specification year date,

4.1.3 Any additional information required by the individual product specification,

4.1.4 Supplementary requirements,

4.1.5 Additional requirements (see 5.2, 5.4, 5.5, 6.1, 7.4, 12.1, 12.3.1, 12.3.3, 12.5.2, 12.6, 14.8, and 18.1).

4.1.6 Additional ordering options provided in the individual product specification, and

4.1.7 Dimensions (diameter, length of point, overall length, finish, shape, threads, etc.).

## 5. Melting Process

5.1 Unless otherwise specified in the individual product specification, the steel shall be fully killed. Use of the basic oxygen process shall be limited to grades containing less than 6 % chromium.

5.2 If a specific type of melting is required by the purchaser, it shall be stated on the purchase order.

5.3 The primary melting may incorporate separate degassing or refining and may be followed by secondary melting

<sup>7</sup> Annual Book of ASTM Standards, Vol 03.03.

<sup>8</sup> Annual Book of ASTM Standards, Vol 03.06.

<sup>9</sup> Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10017.

such as electroslag remelting or vacuum remelting. If secondary melting is employed, the heat shall be defined as all of the ingot remelted from a single primary heat.

5.4 Steel may be cast in ingots or may be continuously cast. When steel of different grades is continuously cast identification of the resultant transition material is required. The steel producer shall remove the transition material by an established procedure that positively separates the grades. Should the purchaser deem it necessary to have the transition zone of two heats of the same grade which are continuously cast discarded, the purchaser shall invoke Supplementary Requirement S53.

5.5 *Quality*—The steel producer quality control procedures shall provide sufficient testing of carbon and alloy steels in accordance with Method E 381 or other suitable method as agreed upon between the purchaser and the producer to assure the internal quality of the product.

5.5.1 *Ingot Cast Product*—Visual examination of transverse sections shall show no imperfections worse than the macrographs of Method E 381 S4–R4–C4 or equivalent as agreed upon. Distinct zones of solidification shall not be present.

## 6. Materials and Manufacture

6.1 Bars shall be produced in accordance with Specifications A 29/A 29M or A 484/A 484M as applicable. Finish (hot or cold, ground, rough turned, drawn, etc.) shall be at the option of the manufacturer unless otherwise specified.

6.2 Fasteners shall be produced in accordance with the product specification.

## 7. Chemical Composition

7.1 *Chemical Analysis*—Heat or product chemical analysis shall be in accordance with Test Methods, Practices, and Terminology A 751.

7.2 *Heat Analysis*—An analysis of each heat of steel shall be made by the steel manufacturer to determine the percentages of those elements specified in the individual product specification. If secondary melting processes are employed, the heat analysis shall be obtained from one remelted ingot or the product of one remelted ingot of each primary melt. The chemical analysis thus determined shall conform to the requirements of the individual product specification. Product analysis (check analysis) tolerances shall not be applied to heat analysis requirements.

7.3 *Product Analysis*—When performed, by manufacturer, purchaser, end user, and so forth, samples for analysis shall be taken from midway between center and surface of solid parts, midway between inner and outer surfaces of hollow parts, midway between center and surface of full-size prolongations or from broken mechanical test specimens. The chemical composition thus determined shall conform to the limits of the product specification, within the permissible tolerances found in Tables 5 and 6 of Specification A 29/A 29M and Table 1 of Specification A 484/A 484M as appropriate for the grade being supplied. When multiple samples are taken from the same lot for product analysis individual elements shall not vary both above and below the specified range.

7.4 For continuous cast materials the requirements of 8.2 or 8.3, as appropriate, of Specification A 788 shall be met.

7.5 Steels with intentional additions of lead, bismuth, or

tellurium shall not be supplied or used. Steels with intentional additions of selenium may only be supplied or used when specifically called out in the product specification.

7.6 The starting material shall not contain any unspecified elements, other than nitrogen in austenitic stainless steels, for the ordered grade(s) to the extent that it then conforms to the requirements of another grade for which that element is a specified element having a required minimum content.

## 8. Mechanical Properties

8.1 *Method of Mechanical Tests*—All tests shall be conducted in accordance with Test Methods and Definitions A 370 unless otherwise specified.

8.2 For the purpose of determining conformance to the product specification requirements, specimens shall be obtained from the production material, or, in the case of forgings, from separately forged test blanks prepared from the stock used to make the finished product. Heat treatment shall be completed prior to removal of material for mechanical testing.

8.3 If separately forged test blanks are used, they shall be of the same heat of steel, be subjected to substantially the same reduction and working as the production forging they represent, be heat treated in the same furnace charge and under the same conditions as the production forging, and be of the same nominal thickness as the maximum heat treated thickness of the production forging.

8.4 *Bars*—Tension and impact tests representing bar stock shall be taken in accordance with the requirements of Annex A1 of Test Methods and Definitions A 370. Impact tests are not required on bars ½ in. and under in diameter.

8.5 *Fasteners, Machined from Heat Treated Bar*—Mechanical properties of fasteners machined from heat treated bar shall be represented by the tests run on the bar in accordance with 8.4.

8.6 *Fasteners, All Classes—Produced by other methods*—When fasteners have been produced by forming, when they have been subjected to heat treatment, or when the nominal thread size falls into a different diameter range than that of the starting bar as shown in the applicable specifications, then tests shall be run on material taken from those fasteners.

8.6.1 Tension test specimens taken from finished fasteners shall be machined to the form and dimensions and from the positions shown in Annex A3 of Test Methods and Definitions A 370. Impact tests are not required on material from externally threaded fasteners when the thread diameter is ½ in. and under.

## 9. Hardness Requirements

9.1 The material shall conform to the hardness requirements prescribed in the product specification. Hardness testing shall be performed in accordance with Test Methods and Definitions A 370.

9.2 Tensile tests prevail over hardness tests in the event a conflict exists relative to minimum strength unless otherwise specified in the product specification.

## 10. Tensile Requirements

10.1 *Bars and Specimens Machined From Fasteners*—The material shall conform to the tensile property requirements



prescribed in the product specification.

10.1.1 When the dimensions of the material to be tested will permit, the tension test specimens shall be machined to the form and dimensions of the standard 2-in. [50-mm] gage length tension test specimen described in Test Methods and Definitions A 370.

10.1.2 When the dimensions of the material to be tested do not permit full size samples, small size specimens meeting the requirements of Test Methods and Definitions A 370 shall be used.

10.2 *Proof Load*—Nuts shall be capable of withstanding the proof loads specified in the product specification.

## 11. Impact Requirements

11.1 The material shall conform to the impact requirements prescribed in the product specification.

11.2 Sampling for impact testing shall conform to the product specification.

11.3 The impact test specimen shall have the form and dimensions shown in Fig. 10 of Test Methods and Definitions A 370 for the Charpy V-notch specimen, Type A. The longitudinal axis of the specimen shall be parallel to the direction of rolling or, in the case of forgings, to the longest axis of the component the test bar represents. The notch shall be located on the test specimen surface which most closely approaches a radial direction. The base of the notch shall be as nearly as practicable perpendicular to the longest axis of the component.

## 12. Workmanship, Finish, and Appearance

12.1 The parts shall conform to the dimensions, tolerances and finish as specified on the purchaser's order or in the individual product specification.

12.2 *Bars*—Bars shall meet the dimensional requirements of Specifications A 29/A 29M or A 484/A 484M as applicable.

12.3 *Bolts, Screws, Studs, and Stud Bolts*—Fastener points shall be flat and chamfered or rounded at the option of the manufacturer. The length of the point on studs and stud bolts shall be not less than one nor more than two complete threads as measured from the extreme end parallel to the axis. Length of studs and stud bolts shall be measured from first thread to first thread. Bolts, studs, and bolting material shall be capable of passing inspection in accordance with Specification F 788/F 788M.

12.3.1 *Hex Bolts*—Unless otherwise specified in the purchase order heads shall be in accordance with the dimensions of ANSI B18.2.1 or B18.2.3.6M and the Heavy Hex screw series, should be used, except the maximum body diameter and radius of fillets may be the same as for the heavy hex bolt series. The body diameter and head fillet radius for sizes of heavy hex cap screws and bolts that are not shown in their respective tables in the ANSI specifications may be that shown in the corresponding hex cap screw and bolt tables respectively.

12.3.2 *Socket Heads*—Unless otherwise specified socket head fasteners shall be in accordance with ANSI B18.3 or the applicable metric series.

12.3.3 *Studs and Stud Bolts*—The dimensions and tolerances of studs and stud bolts shall be as specified by the purchaser or the product specification.

12.4 *External Threads*—Threads shall either be formed after heat treatment or heat treatment shall be performed in atmosphere control furnaces.

12.4.1 *Thread Form*—Unless otherwise specified external threads shall be in accordance with ANSI B1.1, Class 2A fit, or ANSI B1.13M, Class 6G fit.

12.4.2 *Inch Series*—Sizes 1 in. and smaller in diameter shall be coarse thread series, and those 1 1/8 in. and larger in diameter shall be eight pitch thread series, unless otherwise specified.

12.5 *Nuts*—Unless otherwise specified nuts shall be hexagonal in shape and the American National Standard Heavy Hex Series shall be used. In addition nuts shall either be double chamfered or have a machined or forged washer face, at the option of the manufacturer, and shall conform to the angularity requirements of the applicable ANSI specification.

12.5.1 *Thread*—Unless otherwise specified threads in nuts shall be in accordance with ANSI B1.1 Class 2B fit or B1.13M Class 6H fit, and shall be gaged in accordance with ANSI B1.2 or B1.3M.

12.5.2 *Inch Series*—Unless otherwise specified, nuts up to and including 1 in. in diameter shall be UNC Series Class 2B fit and nuts over 1 in. nominal size shall be 8 UN Series Class 2B fit.

12.6 If a scale-free bright finish is required, this shall be specified on the purchase order.

## 13. Decarburization

13.1 *Depth*—The depth of decarburization (total + partial) shall be determined after completion of all heat treatment and shall not exceed the limits shown in Specification A 574, regardless of material being tested.

13.2 *Test Method*—The depth of decarburization shall preferably be determined by metallographic etching. The edge of the specimen shall be suitably prepared to preserve the original heat treated surface. The sample shall be polished, etched with a suitable solution (2 to 5 % Nital if carbon or alloy steel, Vilella's reagent if stainless steel, etc.), and examined under a microscope at 100x using an eyepiece graduated in 0.001-in. [0.025-mm] increments. The measured depth of any light etched band shall be taken as the decarburization depth.

13.2.1 *Microhardness Testing*—When the metallographic etch method of 13.2 renders results that are inconclusive, then the microhardness traverse method of Specification A 574 shall be employed. The depth of decarburization is denoted by that radial depth where the hardness decrease is more than the equivalent of three points HRA, when compared to the average microhardness of the base material at a depth equal to or less than 25 % of the diameter or thickness.

13.3 *Alternate*—Depth of decarburization may be determined on the threads of components rather than on the starting material.

## 14. Number of Tests

14.1 *Chemical Analysis*—One test per heat.

14.2 *Tension Tests, Bar, Rod, or Wire or Fasteners, or Both, Machined from Heat Treated Bar, Rod or Wire*—One test per lot (See 3.1.6).

14.3 *Tension Tests, Fasteners Produced as Defined in 8.6*—



The number of machined specimens or full size fasteners tested shall be as follows:

Lot Size (pc)	Sample Size
50 and less	2
51 to 500	3
501 to 35 000	5
Over 35 000	8

14.4 *Decarburization Test, Carbon and Alloy Steel, Fasteners Produced as Defined in 8.6 and Studs Machined from Cold or Hot Rolled and Heat Treated Bar Whose Diameter Prior to Machining Threads is Within 0.06 in. [1.5 mm] in Diameter of the Maximum Thread Diameter*—One test per lot (see 3.1.6).

14.5 *Hardness Tests:*

14.5.1 *Hardness Tests, Bar, Rod, or Wire*—One test per lot.

14.5.2 *Hardness Tests, Fasteners*—The number of fasteners hardness tested per lot, regardless of production technique, shall be as shown in 14.3.

14.6 *Macroetch, Carbon and Alloy Steels Only*—One test per lot.

14.7 *Impact Tests*—Three impact test specimens shall be made for each lot when impact testing is required by the product specification.

14.8 *Other Tests*—The number of tests shall be as specified by the purchaser or the individual product specification.

## 15. Retests and Rework

15.1 If the results of any tension test do not conform to the requirements specified in the product specification, retests are permitted as outlined in Test Methods and Definitions A 370. If the results of a tension test are less than specified because a flaw becomes evident in the test specimen during testing, a retest shall be allowed provided that the flaw is not attributable to ruptures, cracks, or flakes in the steel. Retesting shall be performed on twice the number of samples originally specified.

15.2 When the impact test acceptance requirements of the specification are not met, one retest of three additional specimens from the same test location may be performed. Each individual test value of the retested specimens shall be equal to or greater than the specified minimum average value.

15.3 Repair by welding is prohibited.

## 16. Inspection

16.1 The supplier shall afford the purchaser's inspector all reasonable facilities necessary to satisfy him that the material is being produced and furnished in accordance with this specification and the applicable product specification. Site inspection by the purchaser shall not interfere unnecessarily with the supplier's operations.

## 17. Rejection and Rehearing

17.1 Samples representing material rejected by the purchaser shall be preserved until disposition of the claim has been agreed to between the supplier and the purchaser.

## 18. Certification

18.1 Certification shall include a statement that the material or parts, or both, were manufactured, sampled, tested, and inspected in accordance with the requirements of the individual product specification, including the specification number and year date of issue. In addition, the certification shall include the results of all tests required by this specification, the product specification, and the purchase order. The supplier shall provide additional specific information as required by the product specification or purchase order.

18.2 A certificate printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The content of the EDI transmitted document shall also conform to any existing EDI agreement between the purchaser and the supplier.

18.3 Notwithstanding the absence of a signature, the organization submitting either the EDI transmission or paper copies of certificates of test is responsible for the content of the report.

## 19. Product Marking

19.1 Bars shall be marked in accordance with Specifications A 29/A 29M or A 484/A 484M as applicable.

19.2 Grade and manufacturer's identification symbols shall be applied to one end of studs  $\frac{3}{8}$  in. [10 mm] in diameter and larger and to the heads of bolts and screws  $\frac{1}{4}$  in [6 mm] in diameter and larger. If the available area is inadequate, the grade symbol may be marked on one end and the manufacturer's identification symbol marked on the other end of studs.

19.3 Grade and manufacturer's identification symbols shall be applied to all nuts regardless of size.

19.4 Hollow forgings shall be marked with the heat number or heat symbol and grade.

19.5 When product is altered in a manner which changes specified requirements, it is the responsibility of the current certifying organization to ensure that the product marking is appropriately revised. This includes the removal of the name or symbol of the previous certifying organization.

## 20. Packaging, Package Marking and Loading for Shipment

20.1 Packaging, marking, and loading for shipment shall be in accordance with Practices A 700.

## 21. Keywords

21.1 austenitic stainless steel; bolts, steel; fasteners, steel; nuts, steel; pressure vessel service; steel bars, alloy; steel bars, carbon; steel bars, stainless; steel bolting materials; stainless steel bolting materials; temperature service applications, high; temperature service applications, low; turbine materials

**SUPPLEMENTARY REQUIREMENTS****S50. Product Marking**

S50.1 Grade and manufacturer's identification symbols shall be applied to one end of studs and to the heads of bolts of all sizes. If the available area is inadequate, the grade symbol may be marked on one end and the manufacturer's identification symbol marked on the other end.

**S51. Stress Relieving**

S51.1 A stress relieving operation shall follow straightening after heat treatment. The minimum stress relieving temperature shall be 100° F [55° C] below the tempering temperature. Tests for mechanical properties shall be performed after stress relieving.

**S52. Heat Analysis**

S52.1 An analysis of each remelt ingot shall be made by the steel manufacturer to determine the percentages of those elements specified in the individual product specification. The chemical analysis thus determined shall conform to the requirements of the individual product specification.

**S53. Sequential or Continuous Strand Casting**

S53.1 When multiple heats of the same chemical composition range are sequentially strand cast, the heats shall be separated by an established procedure such that intermix material shall not be supplied.

**S54. Bolts, Studs and Bolting Material for Dynamic Service**

S54.1 Bolts, studs and bolting material for dynamic service shall be examined for surface discontinuities and decarburization.

**S54.2 Surface Discontinuities**

S54.2.1 The surface discontinuities shall conform to Specification F 788/F 788M and the additional limitations in S54.2.2.

S54.2.2 Thread lap inspection shall be performed in accordance with F 788/F 788M Supplementary Requirement S50. The threads shall have no laps at the root, or on the flanks initiating or extending below the pitch line.

S54.2.3 Quench cracks of any depth, any length, or in any location are not permitted.

S54.2.4 Folds at the junction of the head and the shank are not permitted.

**S54.3 Decarburization**

S54.3.1 Decarburization tests shall be conducted as follows, with the same number of tests as the tension test:

S54.3.2 Section the thread area longitudinally through the axis, and mount and polish the cut face in accordance with Methods E 3. Use either optical or microhardness measurements for decarburization. In case of dispute, the microhardness method shall be used.

S54.3.3 For optical measurement, etch the metallographic section in 4 % Nital. Examine the surface of the etched sample

under a microscope at 100X using a measuring eyepiece graduated in 0.001 in. (0.03 mm) increments, or on a ground glass screen or photomicrograph. There shall be no gross decarburization (clearly defined ferrite grains), and the depth of partial decarburization (light etching zone) anywhere below the pitch line shall be less than 5 % of the nominal thread height.

S54.3.4 For microhardness measurement, make hardness tests in accordance with Test Method E 384 on unetched metallographic sections using either a DPH 136° indenter and a 200-gf load, or a Knoop indenter and a 200-gf load. Take measurements at the minor diameter on the thread crest bisector to determine the base metal hardness. On the same or an adjacent thread, take measurements within 0.003 in. (0.08 mm) of the flank surface at the pitch line, and 0.003 in. (0.08 mm) below the thread root. These two hardness readings shall be equal to or greater than the base metal hardness minus 30 DPH or KHN.

**S55. Magnetic Particle Examination**

S55.1 The wet fluorescent magnetic particle examination method shall be applied to 100 % of the lot in accordance with Practice E 1444. Acceptance criteria shall be in accordance with S57.

**S56. Liquid Penetrant Examination**

S56.1 The fluorescent liquid penetrant examination method shall be applied to 100 % of the lot in accordance with Practice E 1417. Acceptance criteria shall be in accordance with S57.

**S57. Acceptance Criteria**

S57.1 Only indications, which have a dimension greater than  $\frac{1}{16}$  in., shall be considered relevant. A linear indication is one having a length greater than three times the width. A rounded indication is one of circular or elliptical shape with a length equal to or less than three times the width. All surfaces examined shall be free of the following:

S57.1.1 Relevant linear indications;

S57.1.2 Relevant rounded indications greater than  $\frac{3}{16}$  in.; and,

S57.1.3 Four or more relevant rounded indications in a line separated by  $\frac{1}{16}$  in. or less, edge to edge.

**S58. Positive Material Identification Examination**

S58.1 Bolting shall receive Positive Material Identification to ensure that the purchaser is receiving bolting of the correct material grade prior to shipment of the bolting. This examination is a method to assure that no material grade mix-up has happened during manufacturing and marking of bolting.

S58.2 Bolting shall receive a Positive Material Identification examination by Guide E 1916.

S58.3 The quantity examined shall be 100 % of the bolting.

S58.4 All bolting that are not of the correct material grade shall be rejected.

S58.5 The method of bolting marking after examination shall be agreed upon between the manufacturer and purchaser.



**ANNEX**

**(Mandatory Information)**

**A1. REQUIREMENTS FOR THE INTRODUCTION OF NEW MATERIALS**

A1.1 New materials may be proposed for inclusion in specifications referencing this Specification of General Requirements subject to the following conditions:

A1.1.1 Application for the addition of a new grade to a specification shall be made to the chairman of the subcommittee which has jurisdiction over that specification.

A1.1.2 The application shall be accompanied by a statement from at least one user indicating that there is a need for the new grade to be included in the applicable specification.

A1.1.3 The application shall be accompanied by test data as required by the applicable specification. Test data from a minimum of three test lots, as defined by the specification, each from a different heat, shall be furnished.

A1.1.4 The application shall provide recommendations for all requirements appearing in the applicable specification.

A1.1.5 The application shall state whether the new grade is covered by patent.

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